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Designing the transition to sustainable energy systems: The Green Islands Project in the Azores

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Green Islands AZORES

Overview

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- **Methodology**
  - The medium-term model
  - The short-term model
- **Corvo case study**
  - Scenarios
- **Results**
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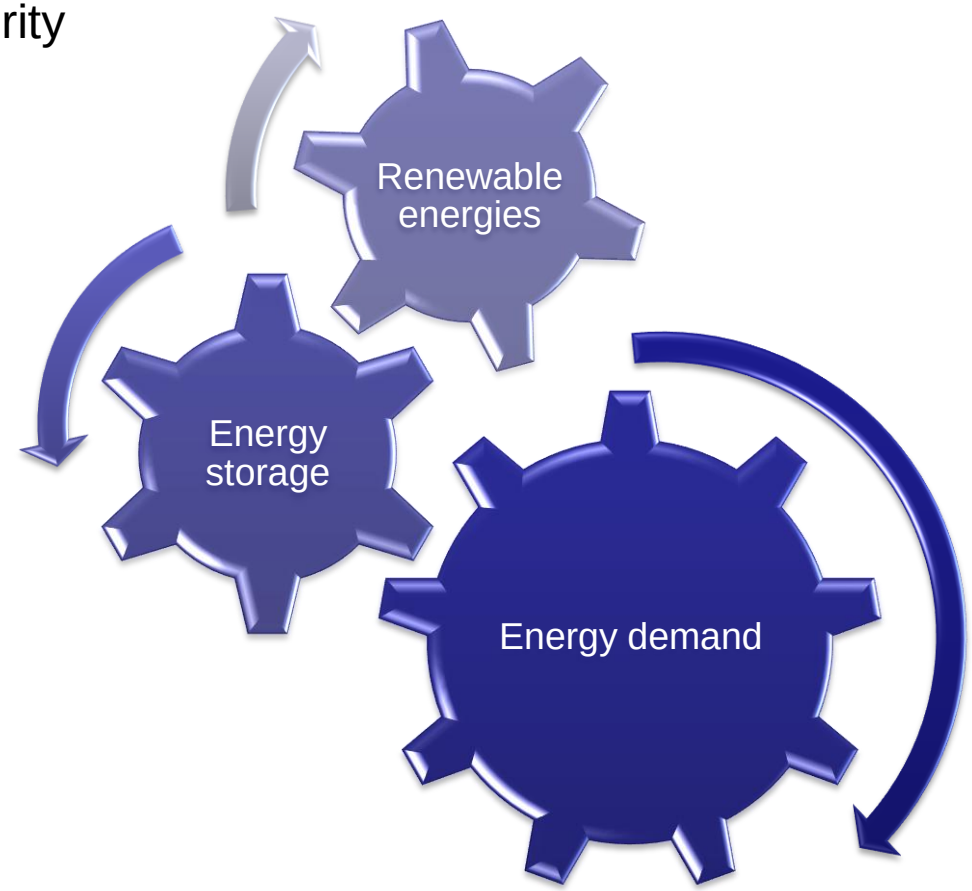
Introduction

To increase sustainability and security of supply, several options must be considered:

- Renewable resources
- Energy storage
- Consumer behavior
- Energy efficiency
- Alternative transportation fuels (biofuels, electricity, others)



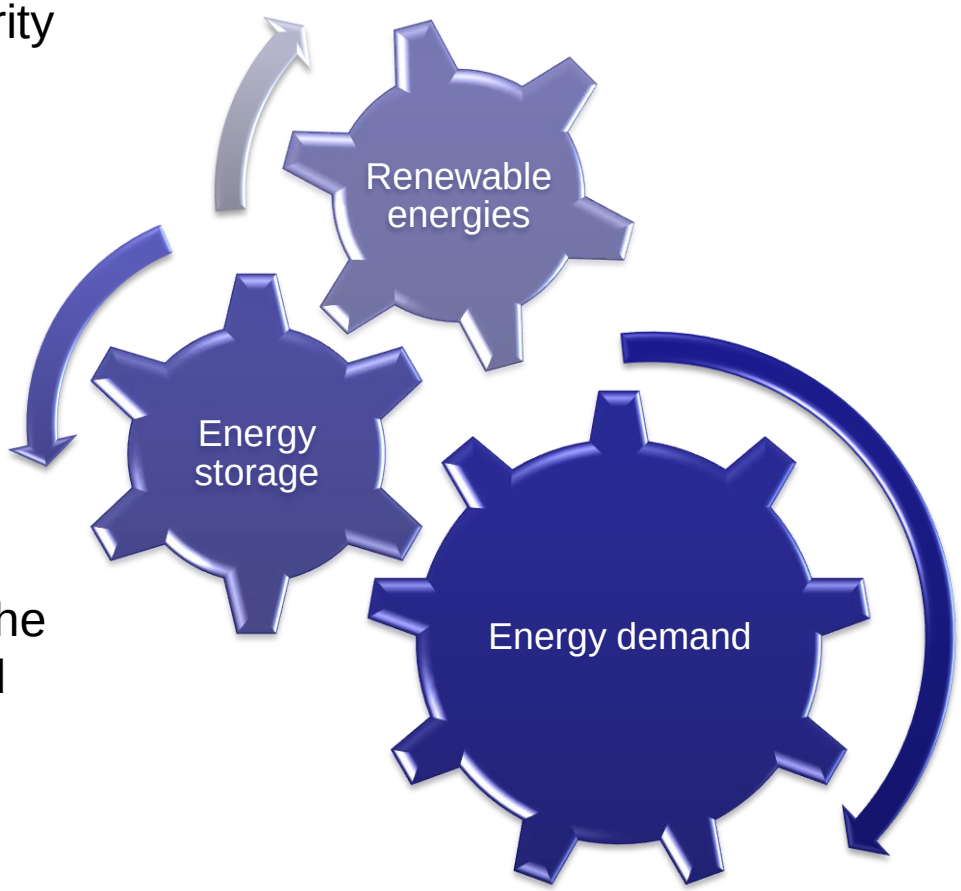
Introduction

To increase sustainability and security of supply, several options must be considered:

- Renewable resources
- Energy storage
- Consumer behavior
- Energy efficiency
- Alternative transportation fuels (biofuels, electricity, others)

To effectively design future energy systems, the interactions between the possible options must be accounted for:

- Intermittency of renewable resources
- Evolution of energy consumption
- Impact of energy efficiency policies
- Charging of electric vehicles



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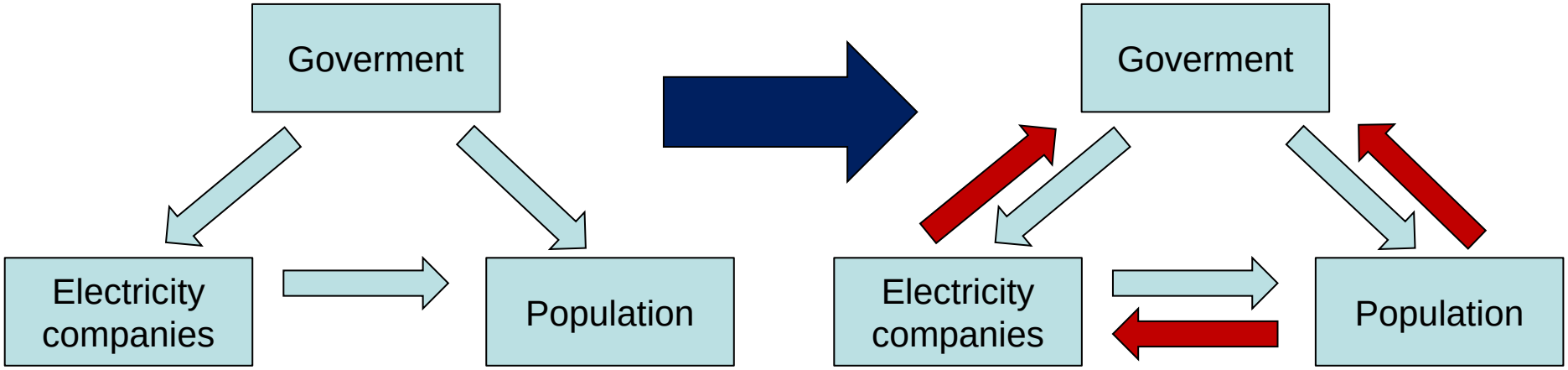
Introduction

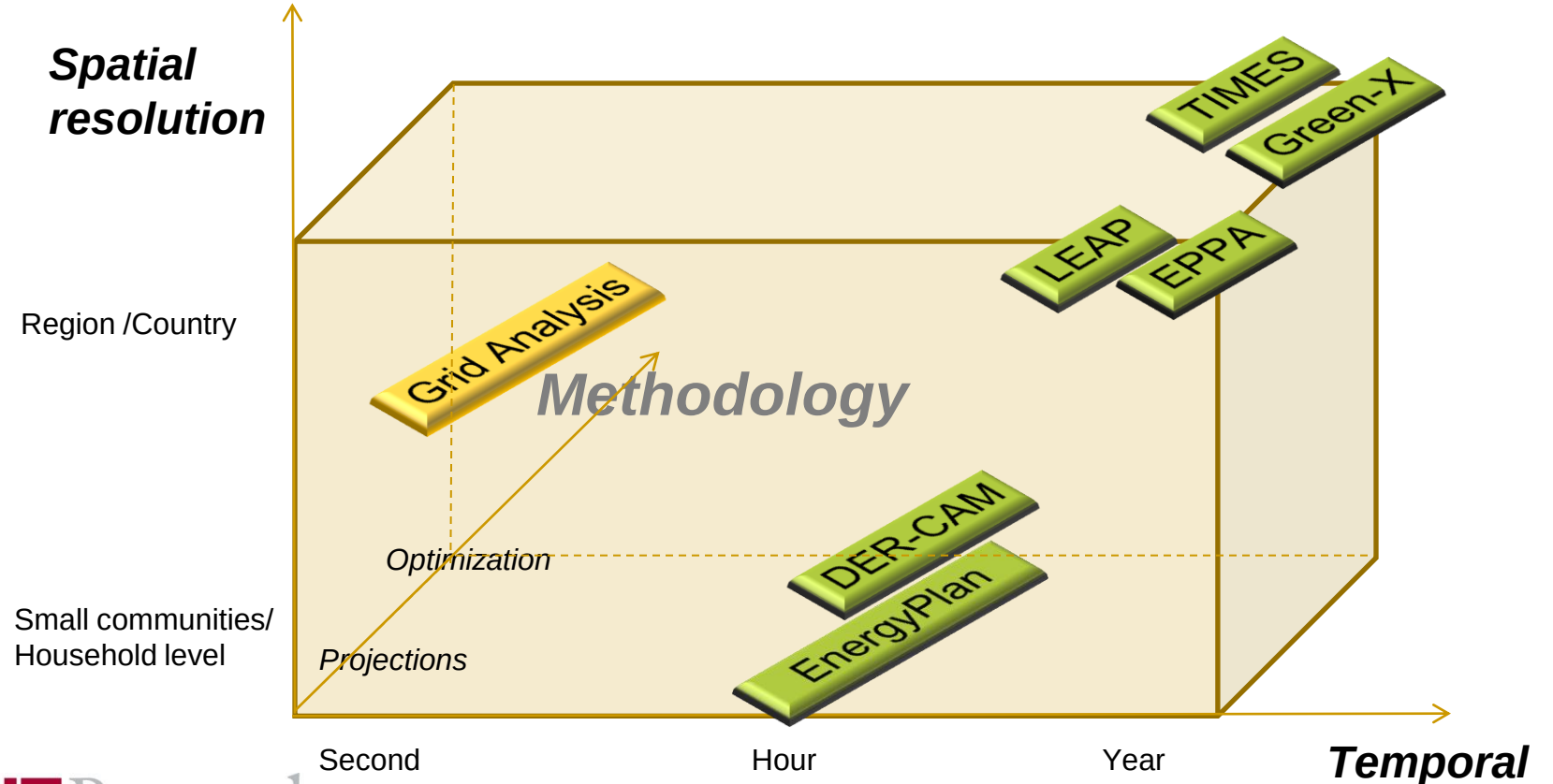
Transition to more dynamic energy systems leads to new synergies between the different agents involved.



A holistic and detailed view of the energy system is necessary

Introduction

To address these issues, a large number of tools have been developed with very different scopes, resolution and algorithms.



Introduction

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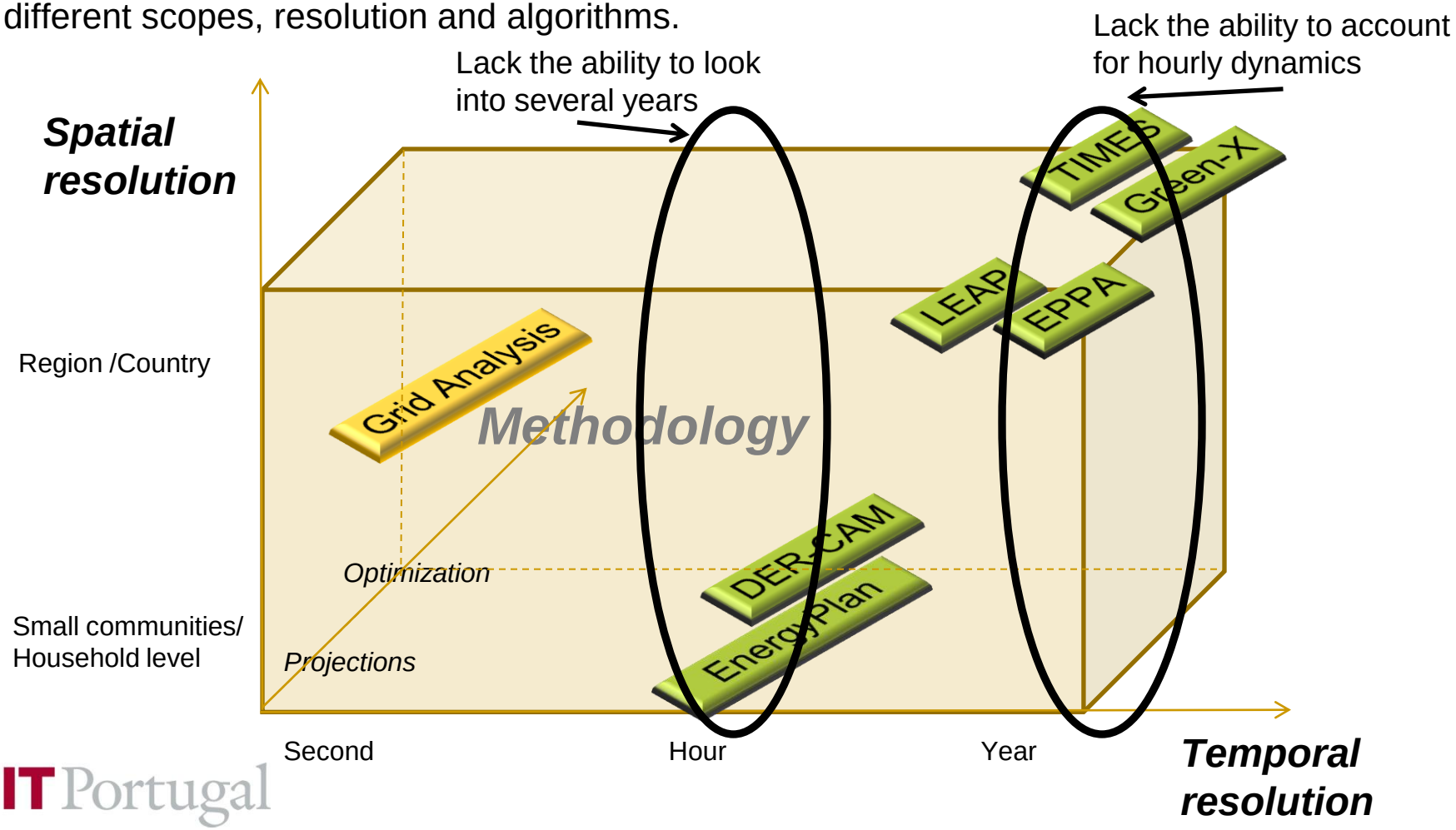
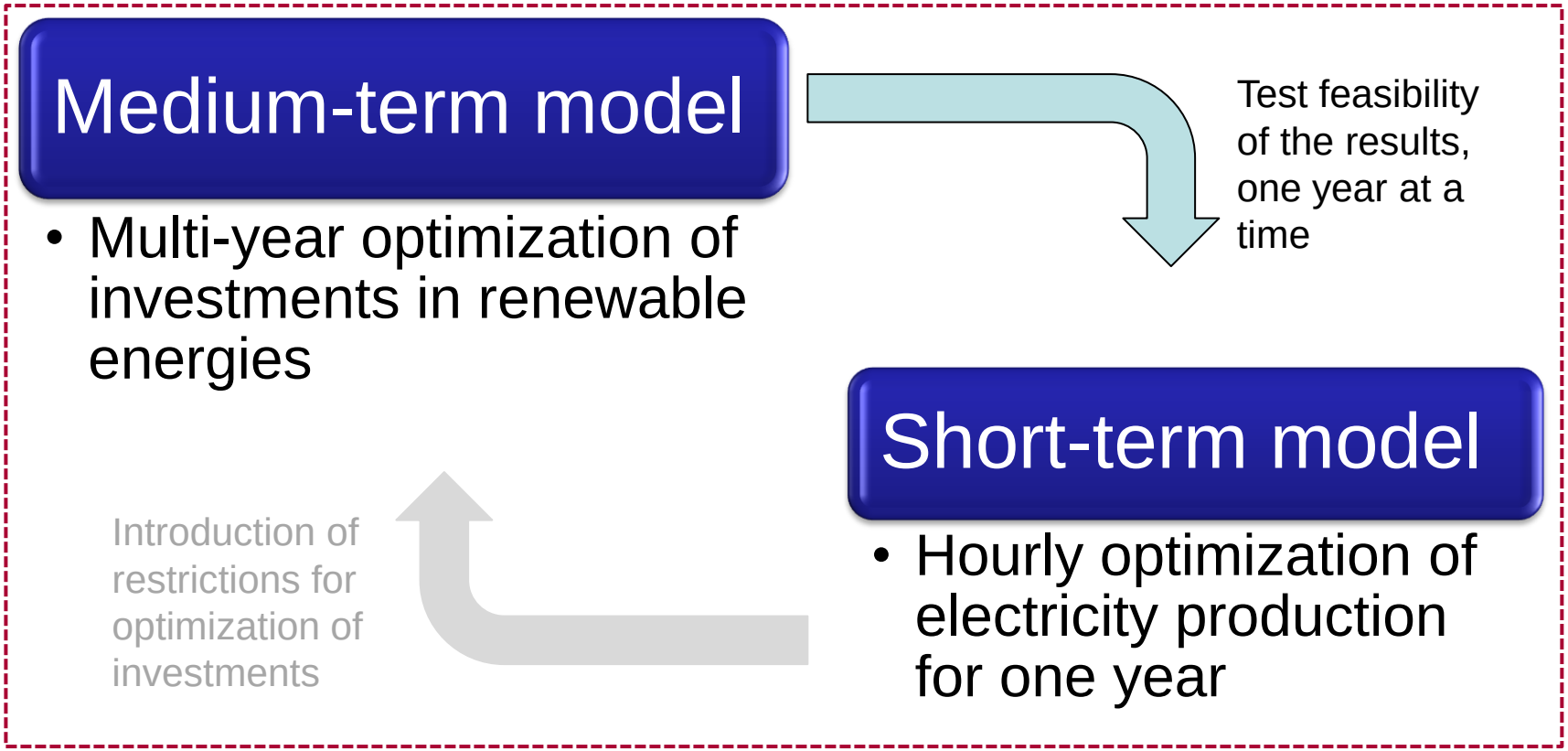


Methodology

In this work, a methodology combining a Medium and a Short-term models is proposed to test different scenarios.

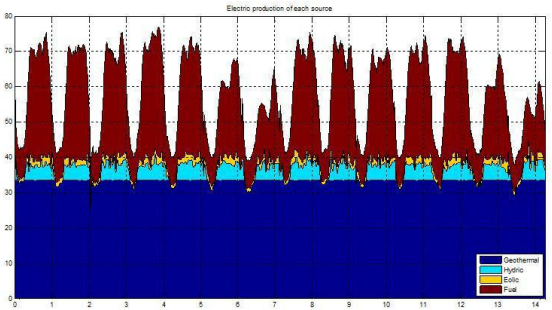


Medium-term model: TIMES

- Some hourly dynamics (considers **4 seasons**, **3 typical days** per season and **24 hours** per day)
- Detailed description of energy consumption:
  - Across different sectors
  - Different types of energy carriers
- Capable of understanding the evolution of the system by optimizing from 2005 to 2040 :
  - Economic growth
  - Fuel prices
  - Energy demand

Short-term model: MATLAB

- One year model with hourly resolution (**365 days**, **24 hours** per day)
- Considers short-term variables with significant impact:
  - Start-up costs and efficiencies for thermal engines
  - Variability of renewable resources
    - Solar
    - Wind
    - Hydro
  - Demand profiles
  - Dynamic demand options (EVs, others)
- Optimization of use of energy storage systems



The Green Islands Project

The Green Islands Project is a collaboration between:

- the MIT-Portugal Program,
- the Regional Government of the Azores,
- several companies and
- other Universities.

The goal is to design sustainable pathways for the islands of the Azores while enabling the creation of a living lab for new technologies.

Find out more at:

http://www.green-islands-azores.uac.pt/

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Corvo case study

Corvo is the smallest island of the Azores archipelago:

- 479 inhabitants in 2007
- 17 Km^2

It is also the most isolated island

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Corvo case study

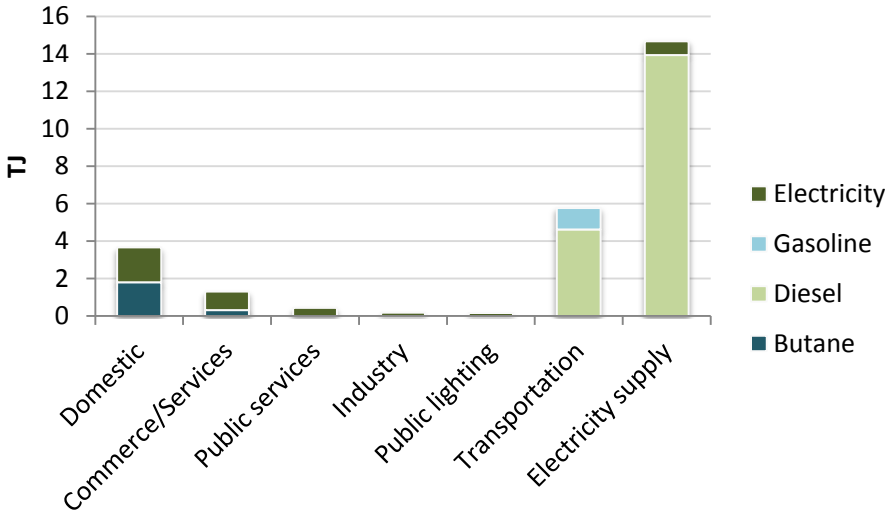
The island is ~100% dependent on fossil fuels for energy: diesel, gasoline and butane (some solar energy for hot water)

High transport costs for fuels:

- Being the smallest and most isolated island, the Government needs to subsidize the import of butane gas for domestic water heating and cooking.

Severe security of supply problems:

- The island can be several weeks without receiving fuels due to bad weather conditions



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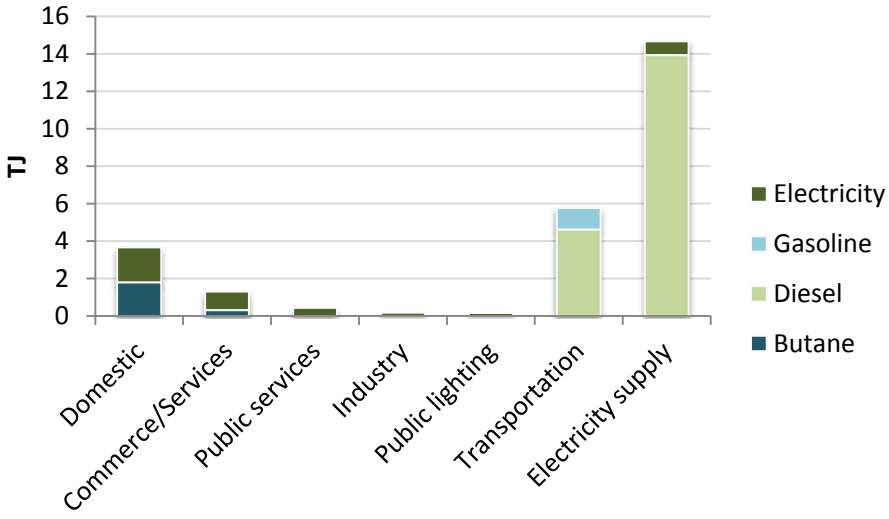
Corvo case study

Corvo is the smallest island of the Azores archipelago

The island is **~100% dependent on fossil fuels** for energy: diesel, gasoline and butane (some solar energy for hot water)

High transport costs for fuels and security of supply issues.

The Government, the local electricity company and other companies have expressed their interest in transforming Corvo into a world wide example on the penetration of renewable energies.



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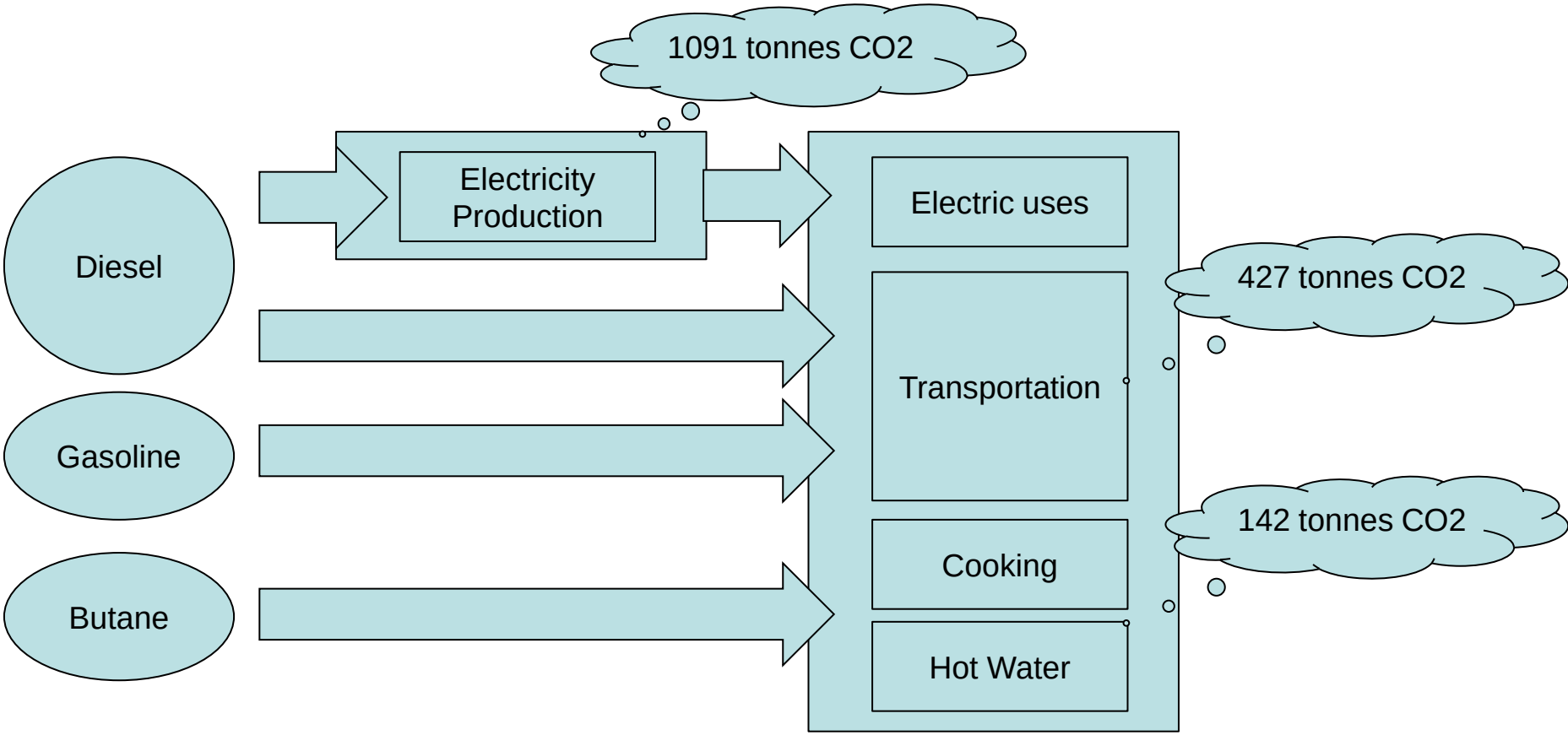
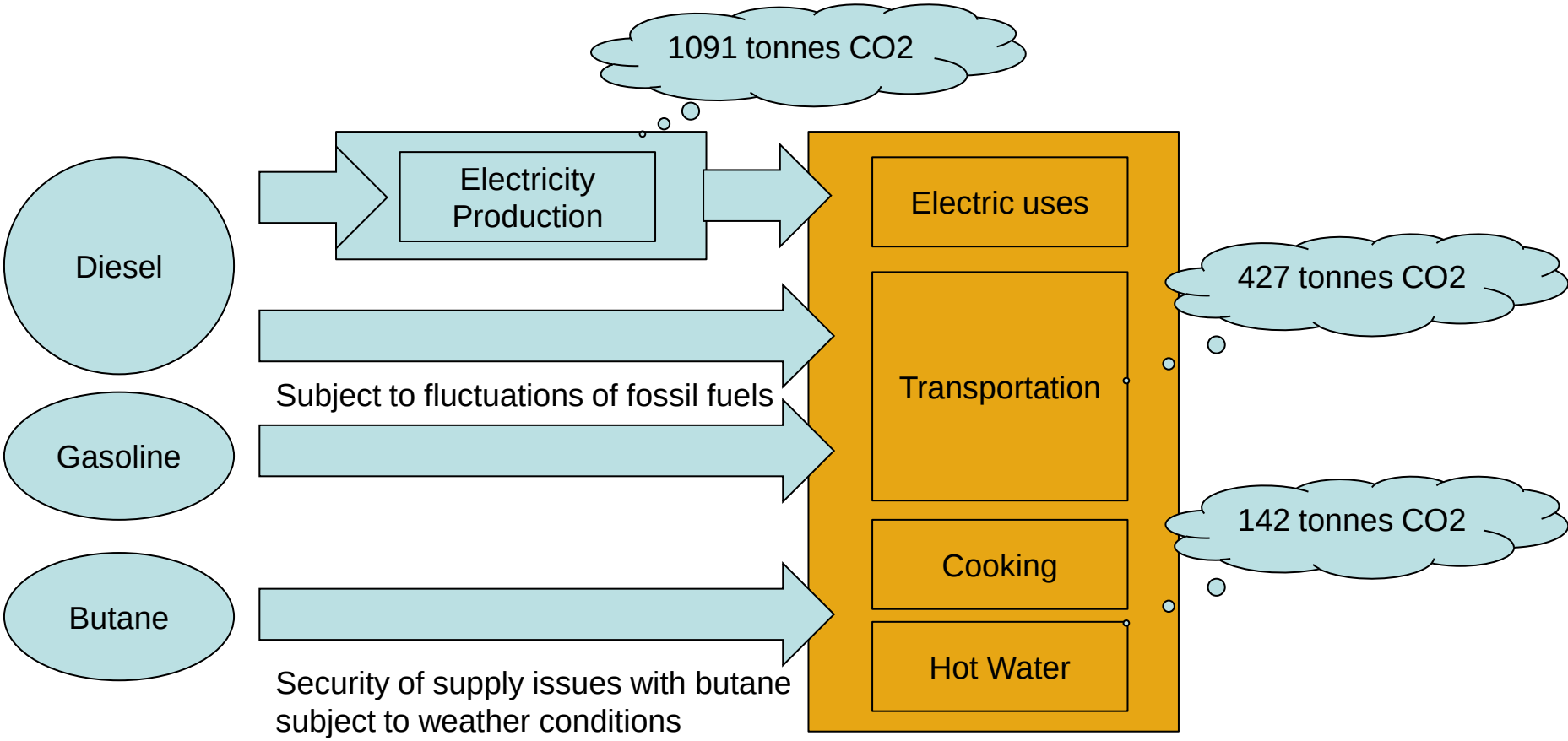
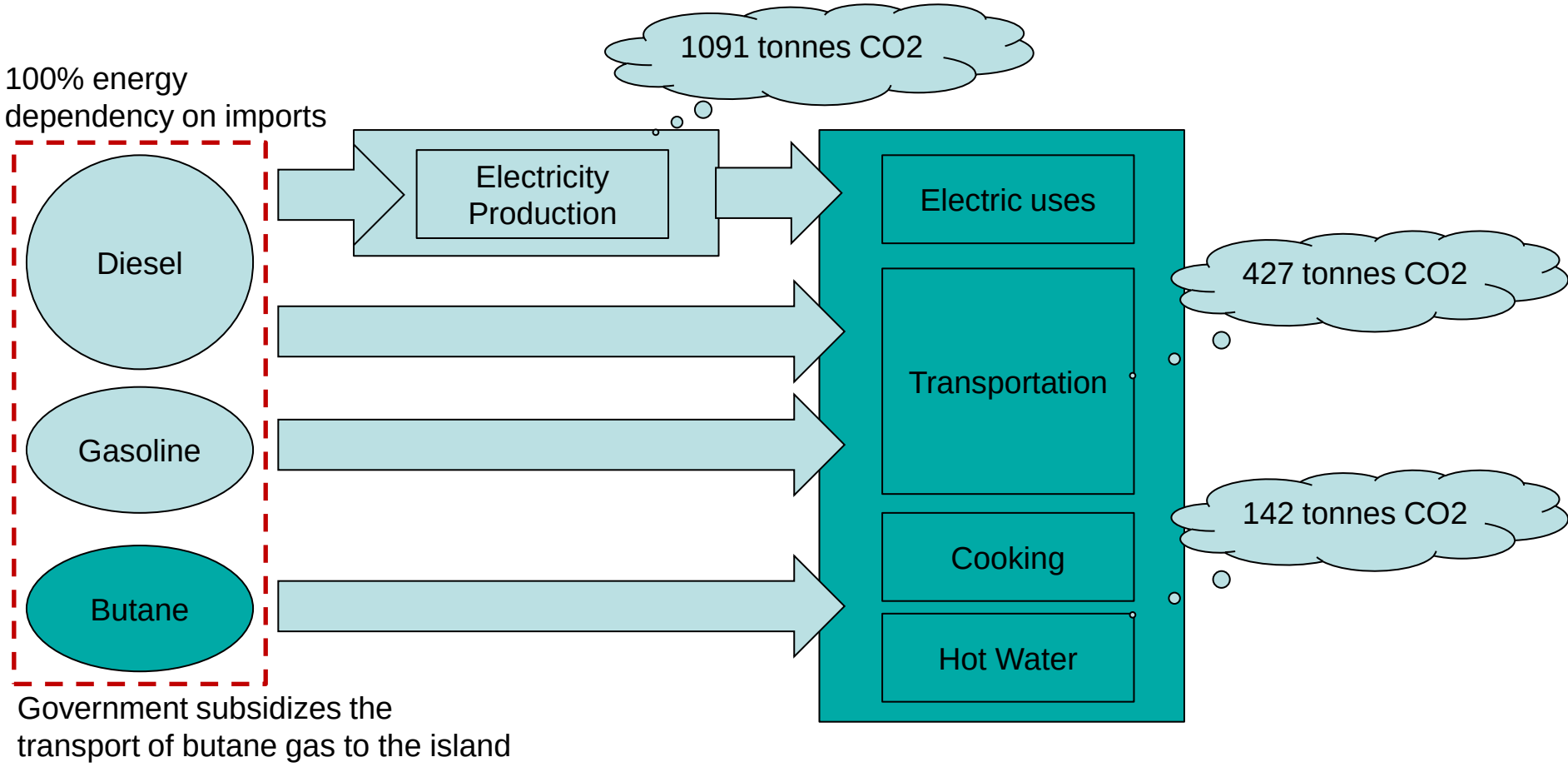
Corvo case study – Situation in 2007



Corvo case study - Population



Corvo case study - Government



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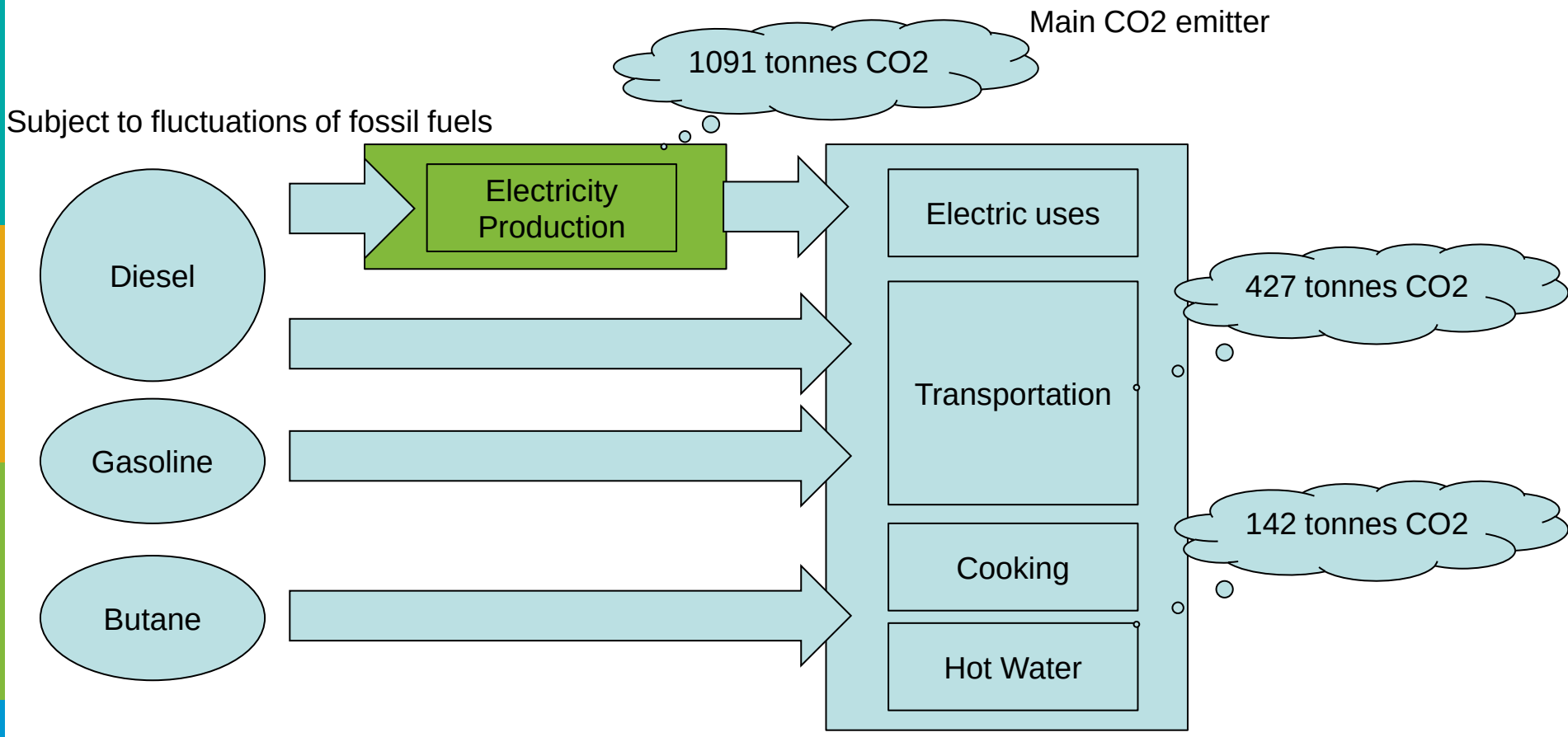
Corvo case study – Electricity company



Scenarios

Scenario based approach (40 scenarios) to study different future energy options:

- 2 scenarios for renewables integration options:
  - No changes in energy consumption: Introduction of renewables only in the electricity sector (wind, solar and pumped storage)
  - Changes in energy consumption: renewable electricity + electrification of cooking + Solar hot water + electric vehicles

Future options

- 5 scenarios for goals on renewable energies in the electricity sector on the long-term model: No goal, low, medium-low, medium-high and high

Policy goals

- 4 scenarios for electricity demand trends and 2 for other fuel consumption:
  - High and low population growth (electricity and fuels)
  - High and low electricity consumption per person (electricity)

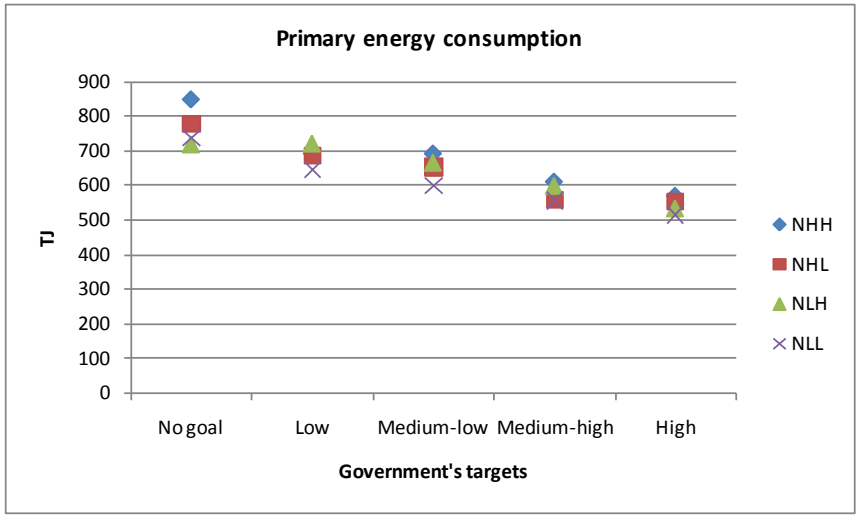
Uncertanties

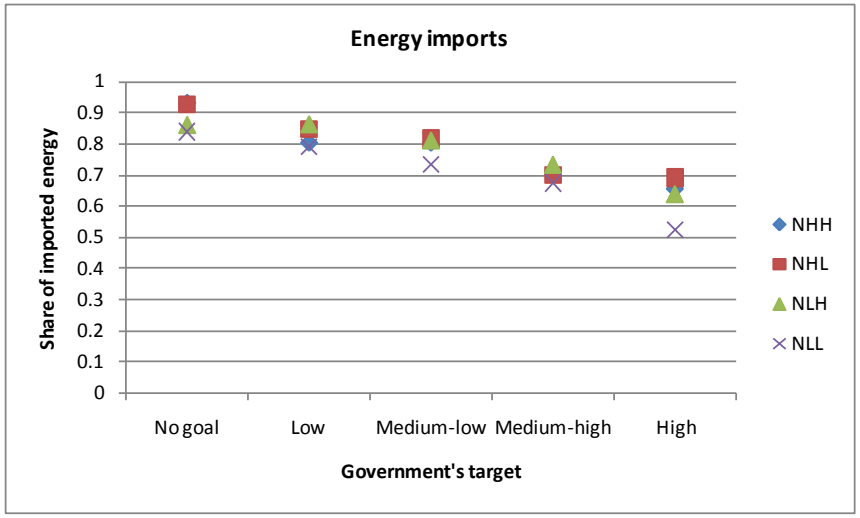
Scenarios

For each of the five scenarios for targets of renewables in electricity production, the following nomenclature was adopted:

	No changes in energy consumption	Changes in energy consumption
High population growth, high electricity consumption per person	NHH	CHH
High population growth, low electricity consumption per person	NHL	CHL
Low population growth, high electricity consumption per person	NLH	CLH
Low population growth, low electricity consumption per person	NLL	CLL

Results – Primary energy consumption





The Governmental targets for renewable energies in electricity production are crucial for reducing primary energy consumption and the imports of fossil fuels:

- Reduction of fuel demand in the electricity sector is the main responsible for such a change
- Primary energy consumption can go down by **~30%**
- Dependecy on fossil fuels can decrease from ~90% (No goal) to **~60%** (High)

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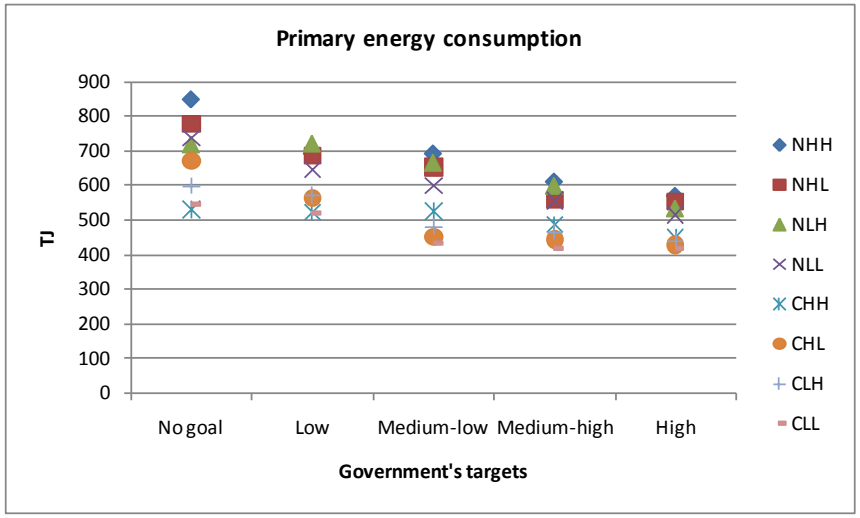
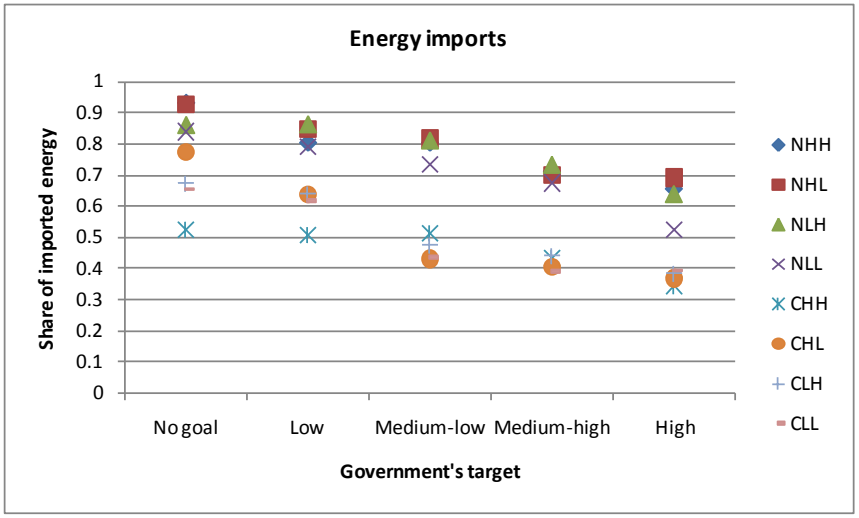
Results – Primary energy consumption





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The introduction of EVs, solar hot water systems and electric cooking can improve the results by reducing energy consumption and imports by **35%**

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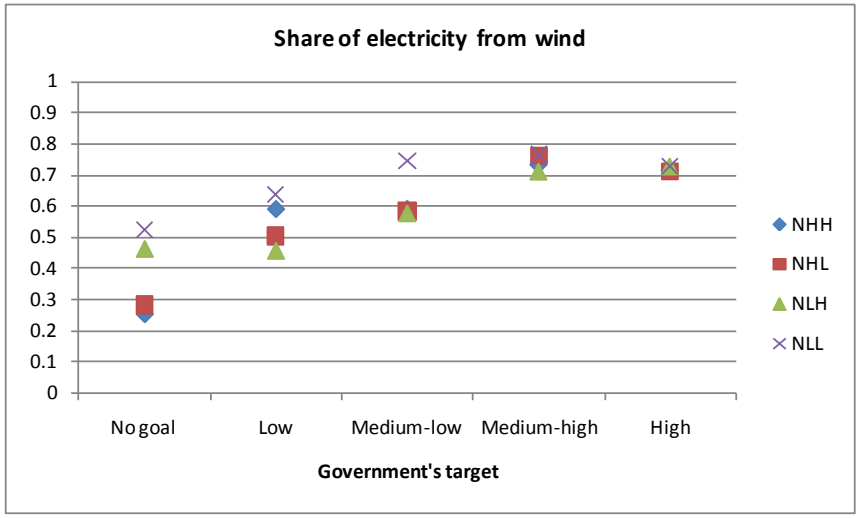
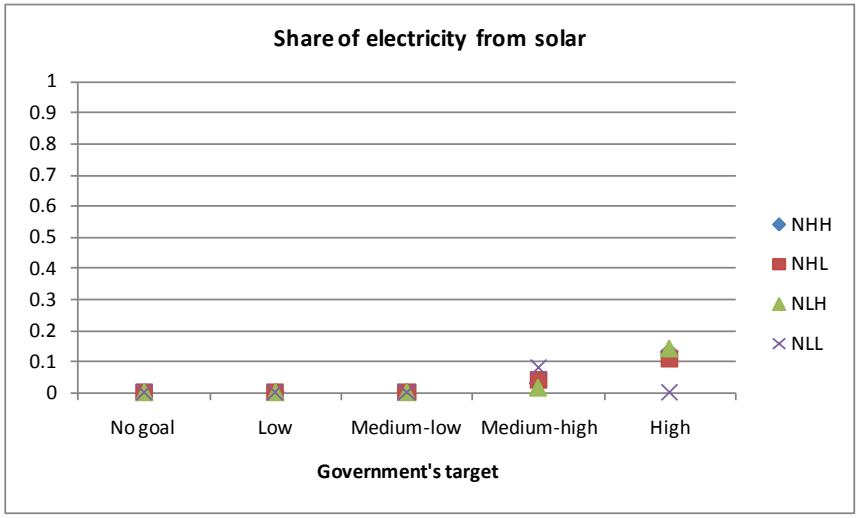
Results – Electricity supply





Wind can be responsible for a large share of electricity production:

- Overall good production throughout the year allow achieving good values of renewable electricity

Solar only comes in for the most restrictive targets:

- Wind is less frequent in the summer time, which is when solar energy is most effective.

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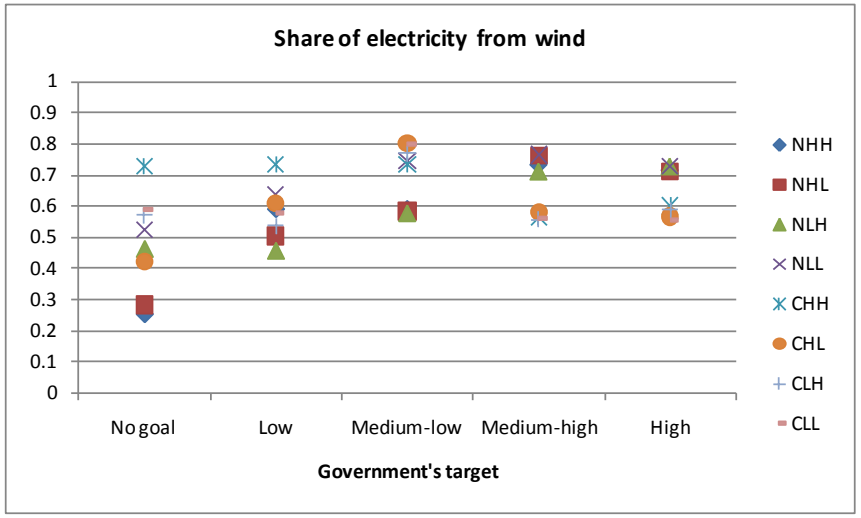
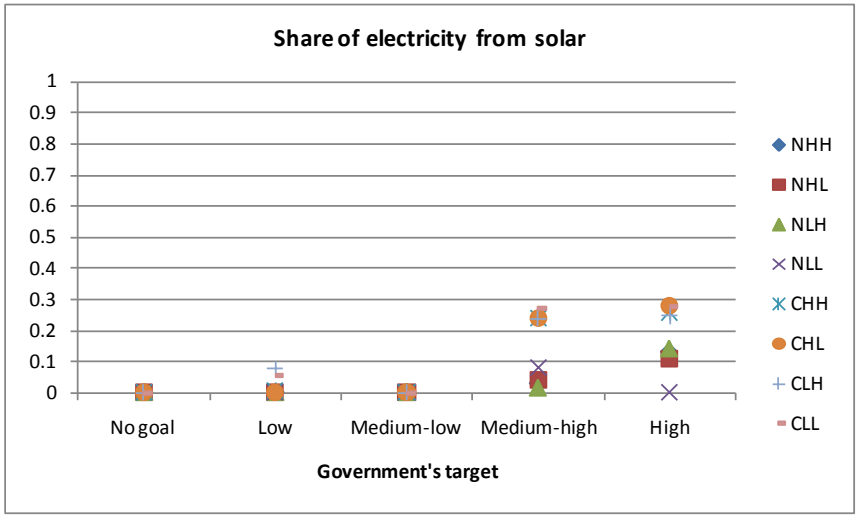
Results – Electricity supply





Wind energy is more used in low Governmental targets, when changes in energy consumption are considered, due to increase in electricity demand.

Lower wind shares in restrictive targets is due to higher use of solar resources, which double when compared to no changes in the consumption sector.

In high renewables targets, the total share of renewables is identical for the scenarios with and without changes in consumption, although there is a difference on the amount of investment on generation capacity.

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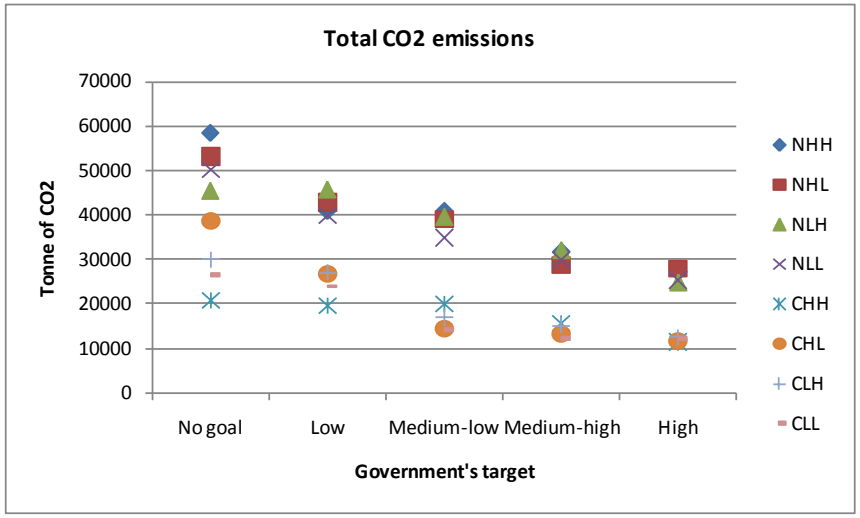
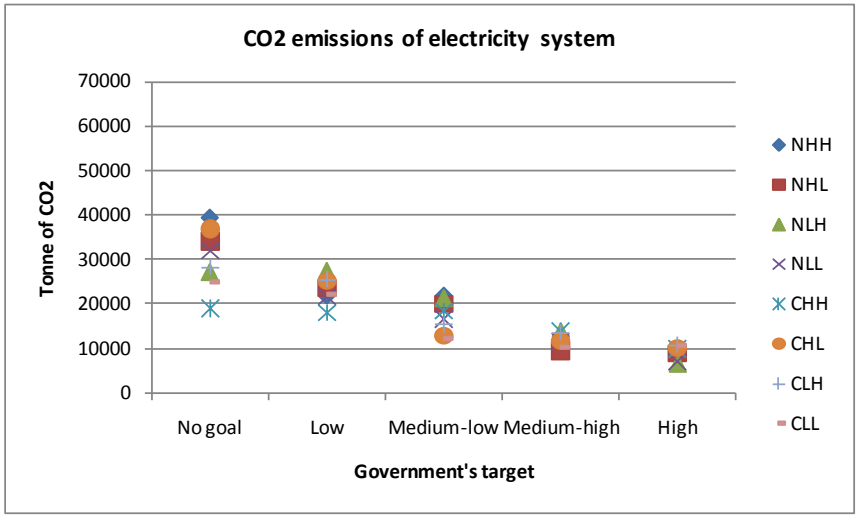
Results – CO_2 emissions





Changes in the energy consumption do not represent big differences for the electricity consumption sector.

The introduction of EVs, solar hot water systems and electric cooking is crucial to further reduce the total amount of CO_2 emitted by the whole system:

- Total CO_2 emissions can be reduced by **~50%** for the time period of 2010-2040

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Conclusions

A multi-level approach in the time resolution of the planning of energy systems is important to understand the matches and mismatches of supply and demand.

The use of a holistic view of the system allows studying the impact of different demand-side measures in the supply side and use a scenario-based approach to understand the best pathways.

Governmental targets are important to increase the penetration of renewable energies.

For Corvo, the involvement of the population in the project is crucial to achieve the most benefits from introducing renewables in the system:

- Reduction of ~35% in primary energy consumption and fossil fuels imports
- High shares of renewable electricity even for low targets from the Government
- Total CO_2 emissions can be reduced by ~50%

End

You can find out more about this and other projects in:
http://www.green-islands-azores.uac.pt/

Any questions? Comments? Ideas?

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